The State of Soil Health in Vermont Project

Presentation to Payment for Ecosystem Services Working Group

9/21/21

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The State of Soil Health in Vermont

Project Goals:

- establish a **baseline of soil health** indicators, carbon stocks and associated ecosystem services in Vermont's agricultural landscapes
- create **standards for soil sampling** across management types and partners so that they will be comparable
- give farmers **contextualized information** about soil health on their farms
- support **collaboration** among the many organizations that work with farmers towards shared goals around soil health
- **build skills & capacity** for soil carbon assessments & measuring soil health

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vermont environmental stewardship PROGRAM

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The State of Soil Health in Vermont

Phase 1 : Analyze existing data

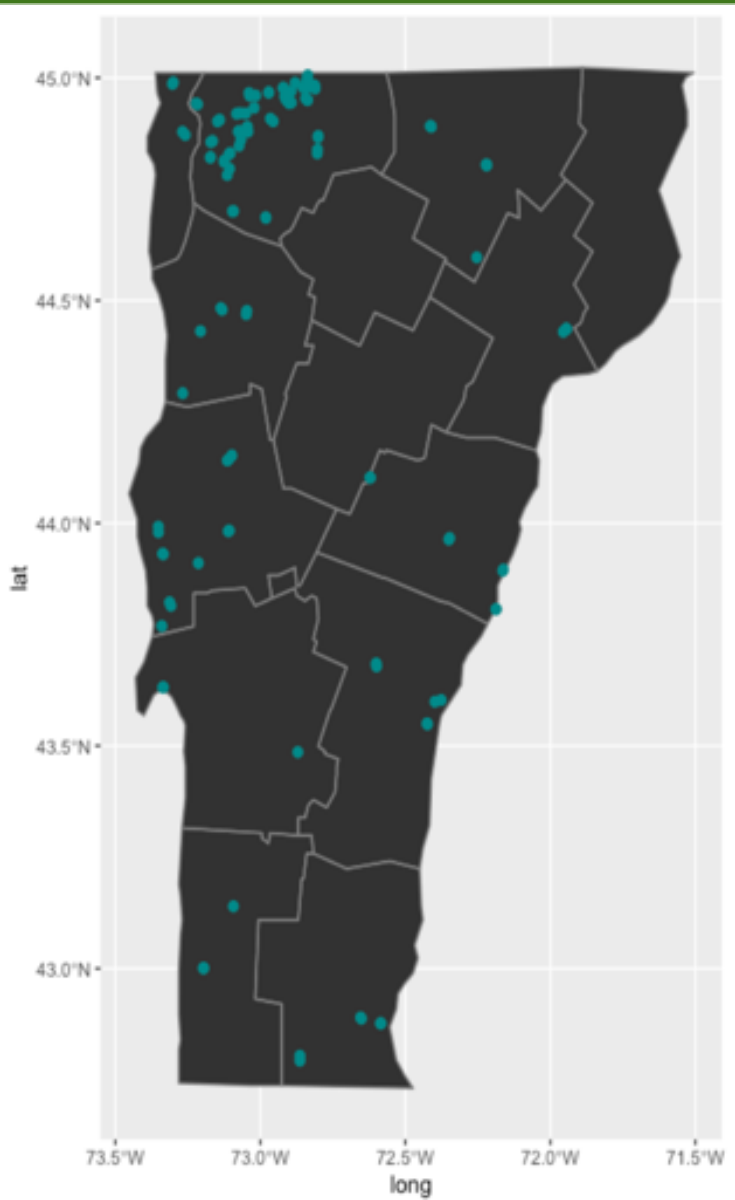
Phase 2 : 2021 Baseline Assessment

- Coordinate data sharing between existing projects
- Establish shared sampling methods, data sharing standards, trust, shared goals
- Assess current range of soil carbon stocks and soil health indicators in agricultural landscapes
- Demonstrate value to stakeholders
- Use as basis for education about ecosystem services and soil health

Phase 3 : 2022 and beyond

- More robust sampling, greater participation
- Responsive to farmers, network liaisons
- Additional measurements & analyses

The State of Soil Health in Vermont



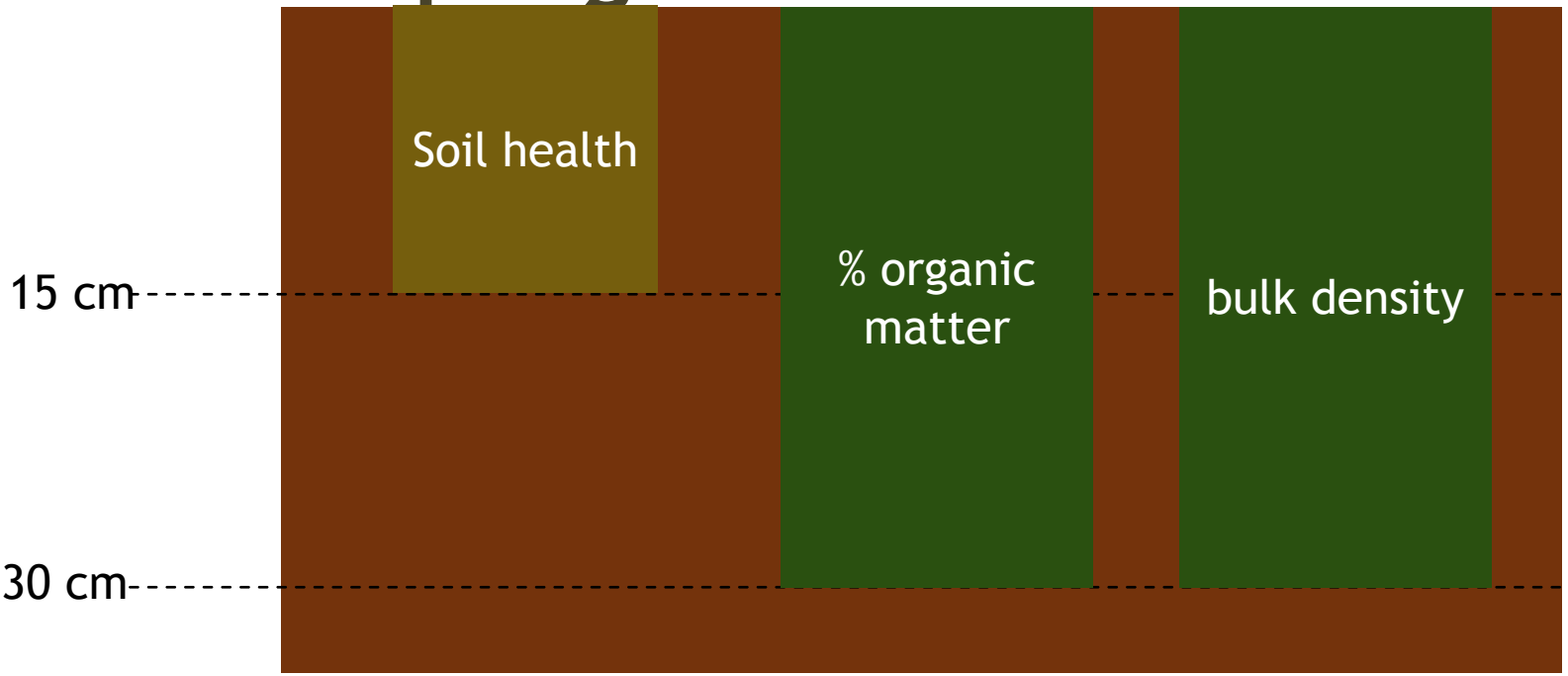
2021 Baseline Assessment

- *Convenience sample* from existing research projects, plus purposeful sampling to reach greater geographic extent of state
- 185+ fields sampled

Analysis:

- What is the current state of soil health on farms?
- What kinds of farm management are associated with the highest levels of soil health?
- Where are the most important places to focus on improvement?
- How do soil texture and management influence soil health indicators, soil carbon stocks and associated ecosystem services?

Soil Sampling



Samples & data for each field:

- one composite soil sample to 15 cm depth for Cornell CASH test, Ecoplate carbon substrate assays (UVM) & carbon fractions (Dartmouth)
- one composite soil sample to 30 cm depth for UVM
- three bulk density cores to 30 cm for UVM
- field management information

The State of Soil Health in Vermont

What are we measuring and what does it mean?

Soil Health (CASH)
- Available water capacity
- Aggregate stability
- Organic matter
- ACE soil protein index
- Soil respiration
- Active carbon
- Soil PH
- Extractable phosphorus
- Extractable potassium
- Minor elements

Soil Carbon Stocks to 30 cm depth
- Bulk density
- Soil Organic Carbon

Biological Functional Diversity
- Ecoplate carbon substrate test

Carbon fractions
- Particulate VS Mineral organic carbon

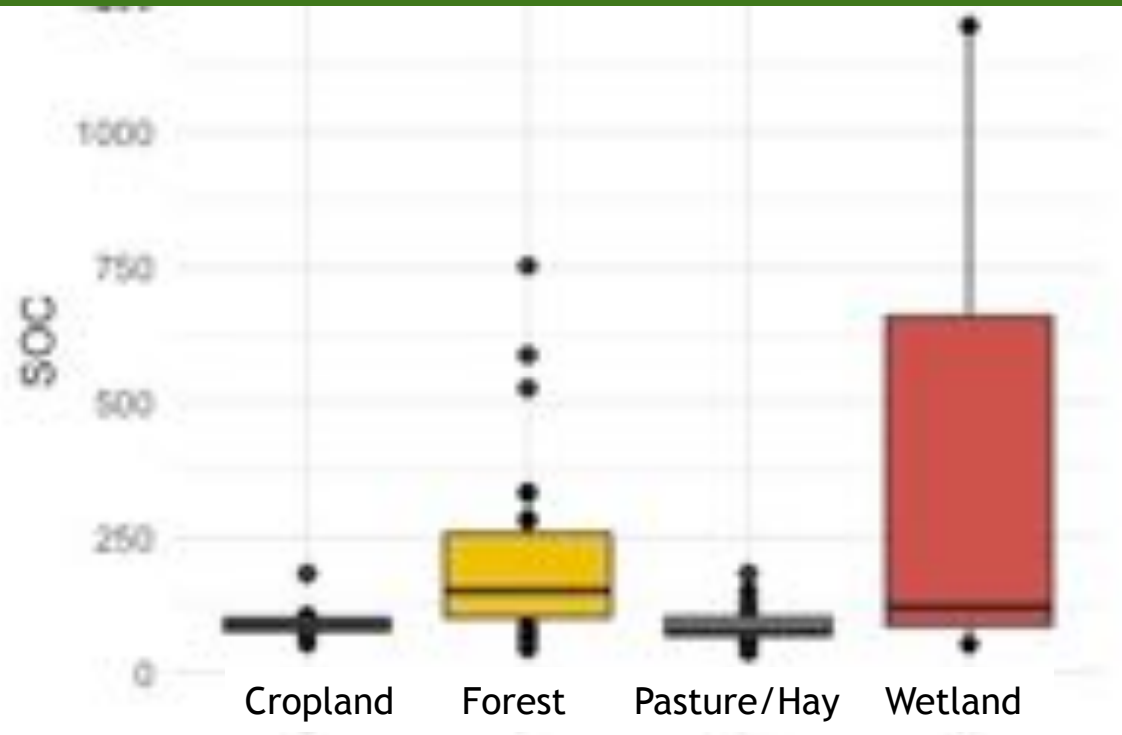
- Nutrient availability
- Ecosystem Services
  - Soil health
  - Resilience to extreme weather
  - Climate regulation
- Biological community in soil
  - Diversity richness
  - Niche partitioning and breadth
- Carbon permanence

Soil Carbon Stocks in Vermont

The University of Vermont

NRCS RaCa soil carbon stock data in Vermont

- 53 sites in Vermont in 2010
- Mean values are skewed by high outliers
- Wetland and forest soils have highest soil carbon content in Vermont.
- Agricultural soils are an opportunity to enhance soil carbon content.



Land Use	number of fields sampled	mean SOC stock		
		5 cm depth	**30 cm depth**	100 cm depth
Cropland	8	23.75	**95.49**	124.37
Forest	27	91.75	**212.31**	NA
Pasture and Hay	15	30.59	**90.45**	132.15
Wetland	3	82.93	**456.50**	1425.81

Soil Carbon Stocks in Vermont agricultural soils

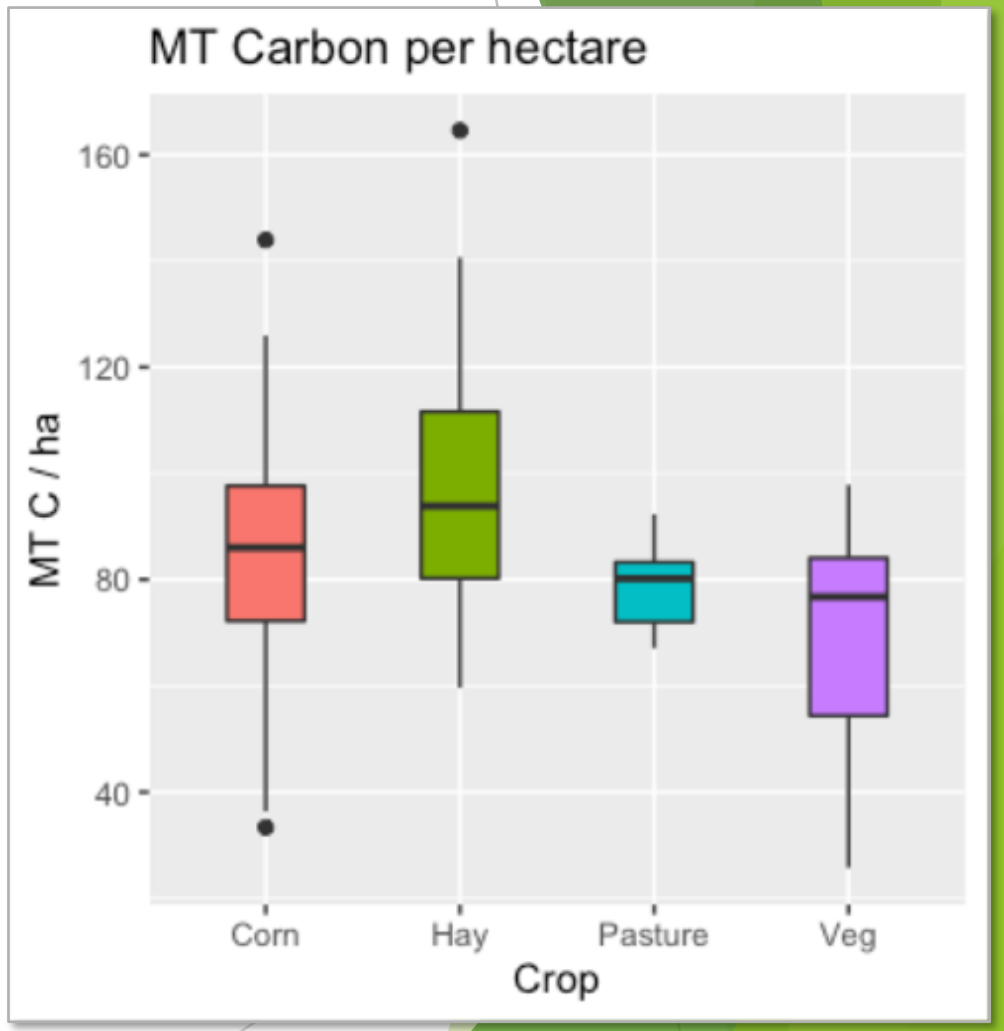
The University of Vermont

Preliminary results from the State of Soil Health 2021 data

- Hay fields have the greatest agricultural soil carbon stocks
- Corn & hay fields had some of the highest soil carbon stocks.
- Vegetable fields have lowest soil carbon stocks
- Management and soil texture also have a strong effect

Soil Carbon Stocks in Vermont Agriculture
MT C/ha to 30 cm depth

Type	n	Min	*Median*	Mean	Max	Standard deviation
Corn	96	33.35	***86.01***	85.52	143.95	21.68
Hay	24	59.64	***93.84***	99.65	164.56	28.34
Pasture	16	67.06	***80.18***	79.00	92.32	9.09
Veg	18	25.73	***76.75***	69.30	97.84	21.60



Soil Organic Carbon in Vermont

The University of Vermont

Comparing existing data on agricultural soils

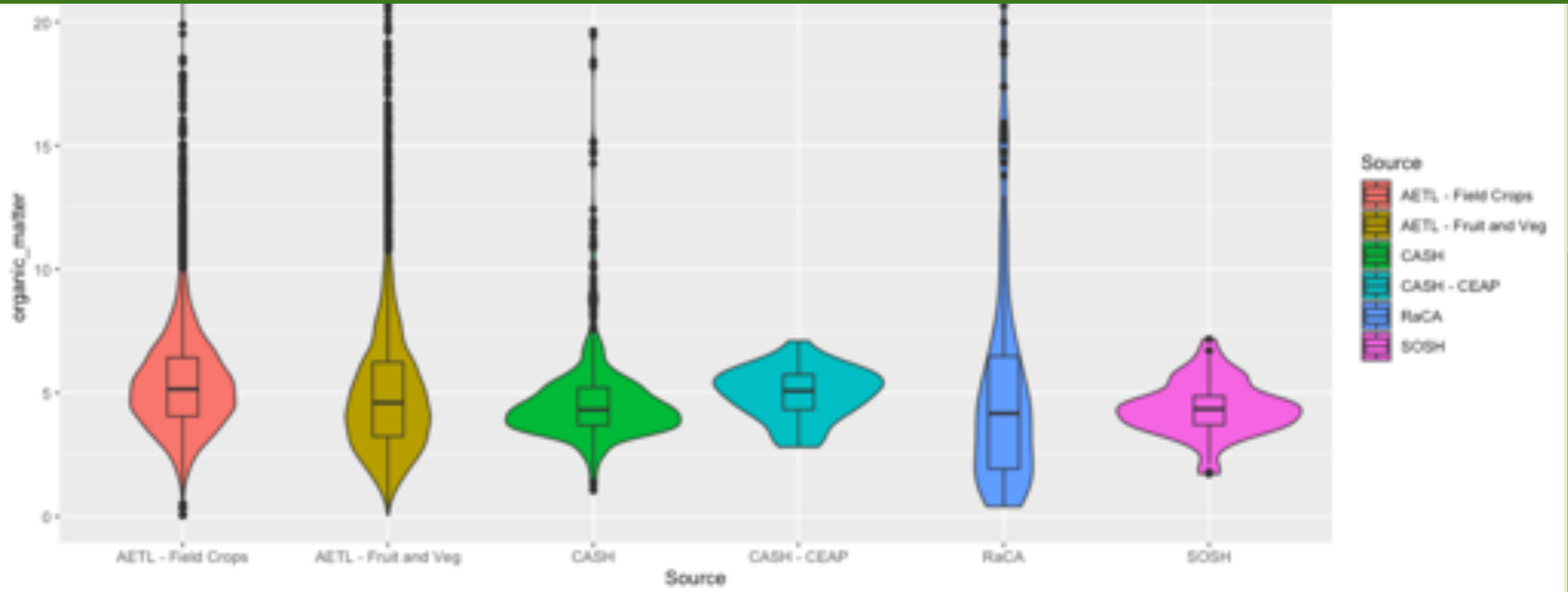
- Organic matter content in Vermont agricultural soils are outstanding
- Climate, soil texture and **management** contribute to high organic matter levels

Soil organic matter levels in hay, pasture and crop fields from available data

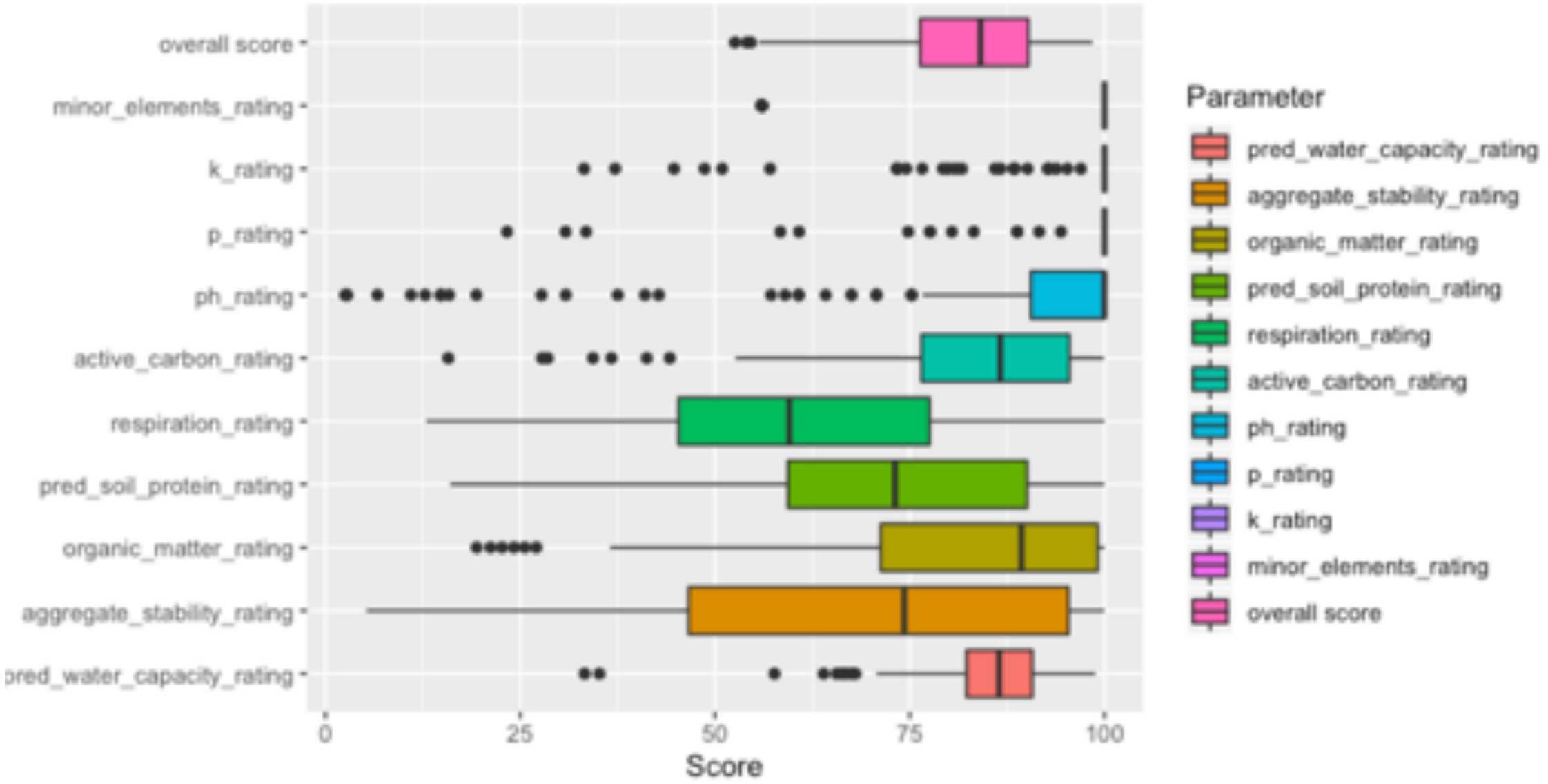
Dataset	n	Average OM%
Vermont - UVM AETL data	9,415	5.3%
Vermont - USDA RaCA data	26	5.6%
Vermont - Cornell CASH data	622	4.8%
Vermont - State of Soil Health 2021 data	145	4.4%
USA - USDA RaCA data	6,236	3.2%

Soil Organic Carbon in Vermont

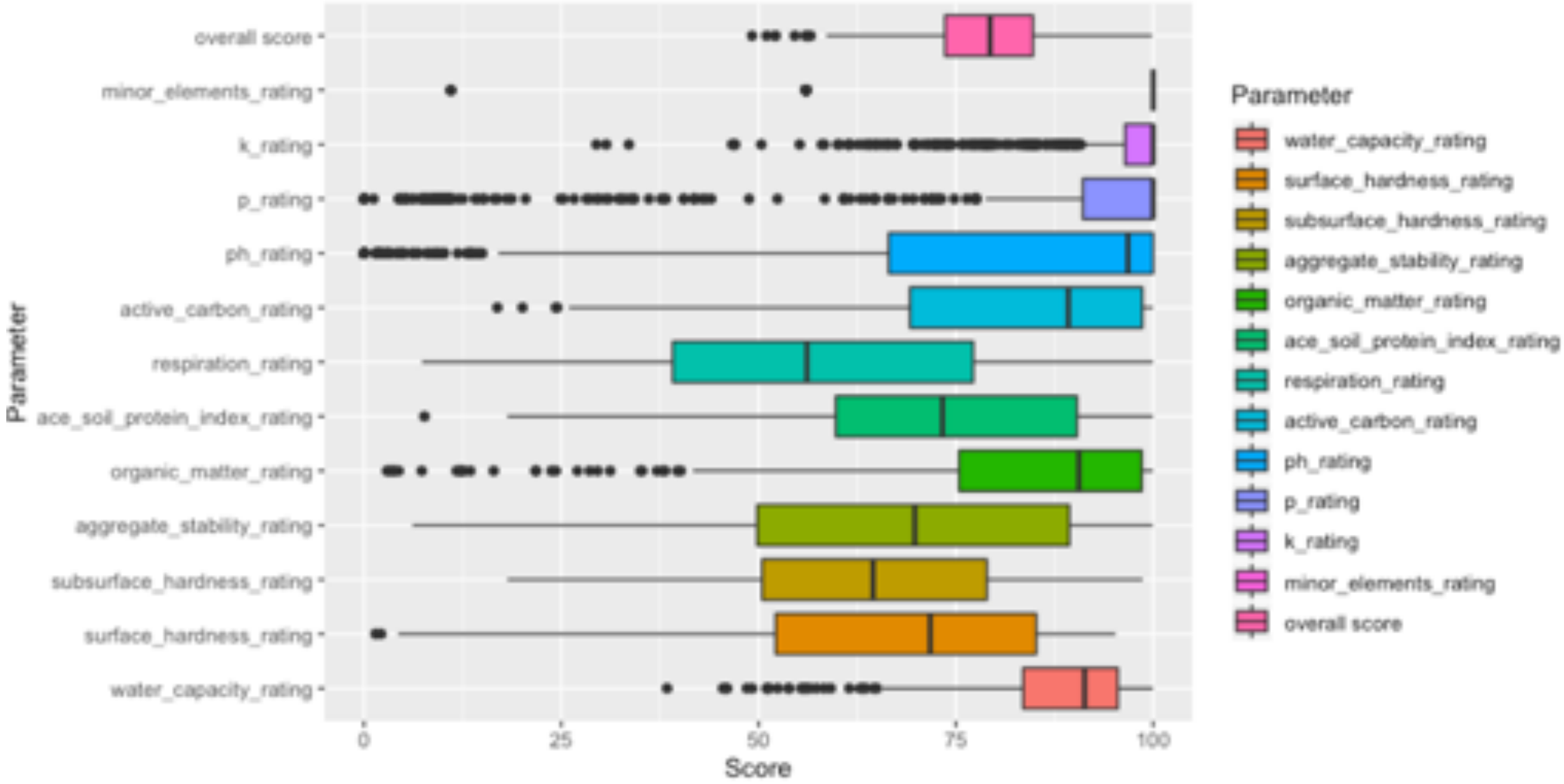
The University of Vermont



- Organic matter content in Vermont agricultural soils from over 26,000 samples in multiple datasets corroborate that the **median and mean organic matter content are over 4%**
- Greater gains are possible. The high end of the interquartile range (Q3) for soil testing data from Vermont is **6.4% organic matter.**



Range of soil health scores in 96 soil samples taken in 2021

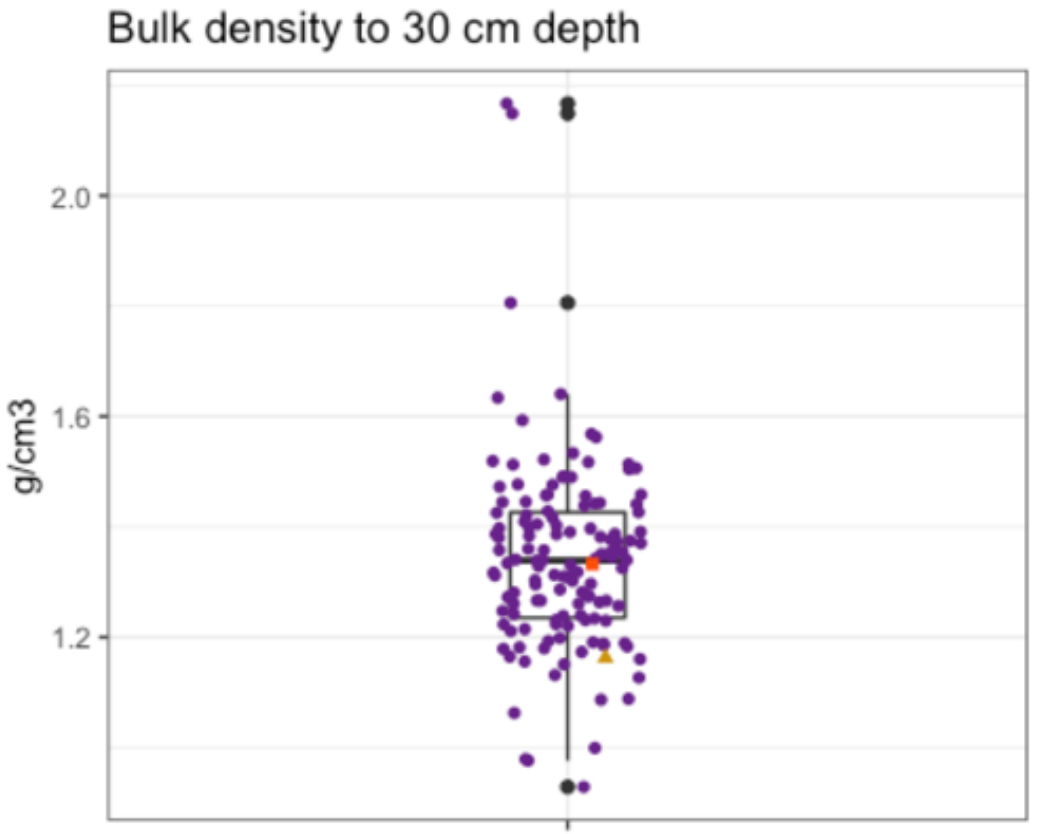


Boxplot of range of soil health scores in 662 Vermont agriculture soil samples taken between 2015 and 2020

Staring to report back to farmers…

Infiltration

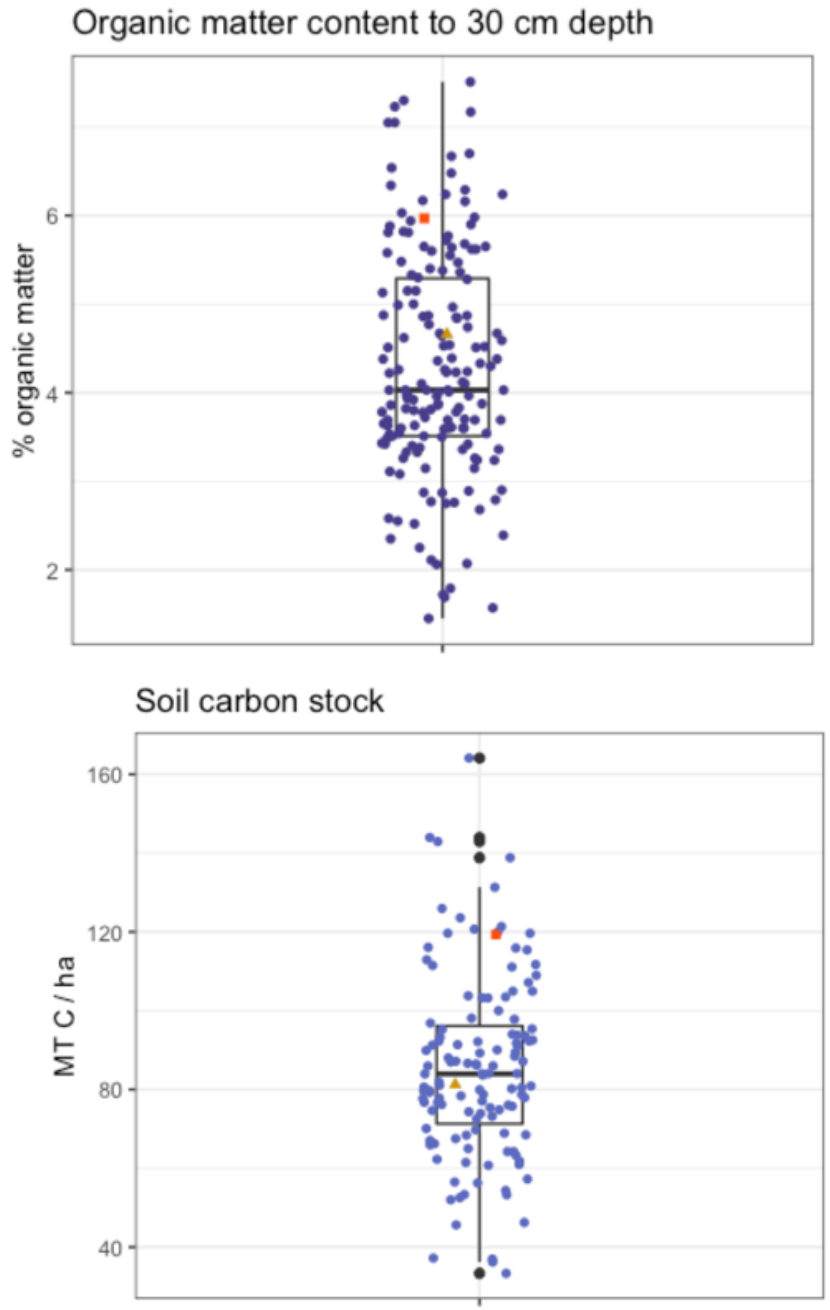
Bulk density is a direct measure of the physical mass of soil in a given volume. It is commonly used as an indicator of compaction. A value of over 1.6 is likely to restrict root growth. Bulk density is also a measure of how much pore space is in your soil. Changes in bulk density can influence the amount of water that will infiltrate into the soil and reduce flooding lower in the watershed. *Lower bulk density numbers mean greater infiltration of water.*



Carbon storage

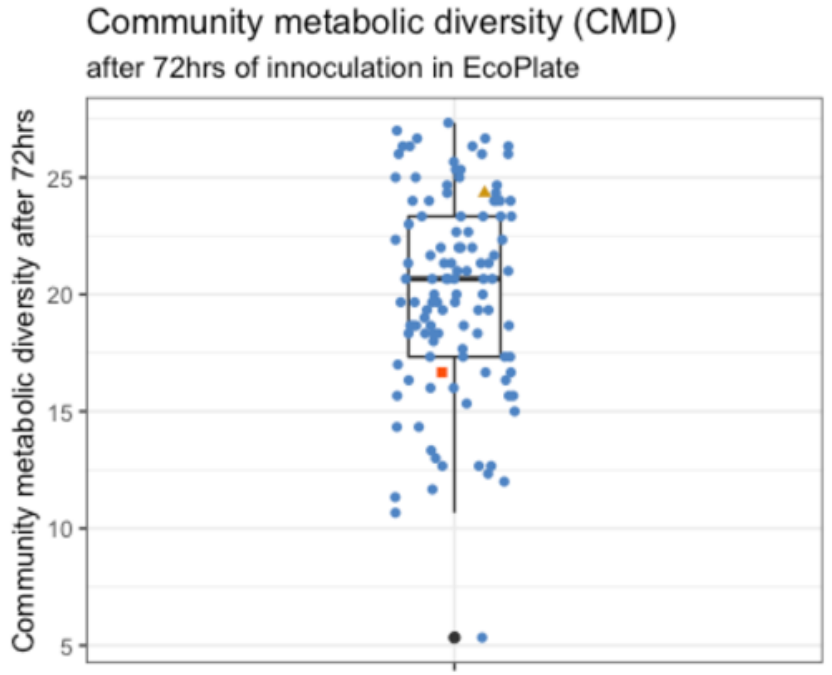
The amount of carbon in the top 30 cm of your soil is estimated by measuring the percept of organic carbon, and the density of the soil. The two measures are combined to calculate an overall amount of carbon in the soil, which is called a carbon stock. Denser soils have greater carbon stock measures.

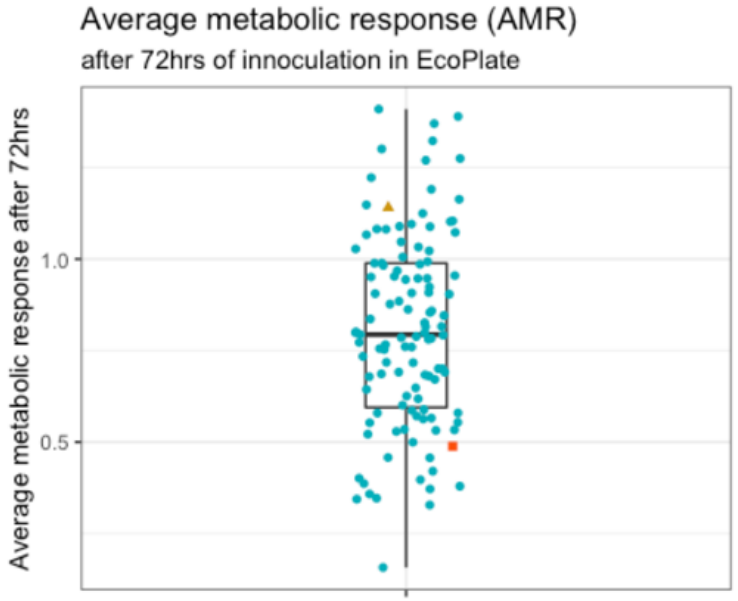
In the table above, we report the soil organic matter content and the bulk density measures we used to calculate soil carbon stocks. We've also reported the equivalent MT CO^2 for the carbon in your soil per hectare to 30 cm depth. This number comes from the molecular weight ratio of carbon to CO_2 , which is 44/12.



Biological diversity

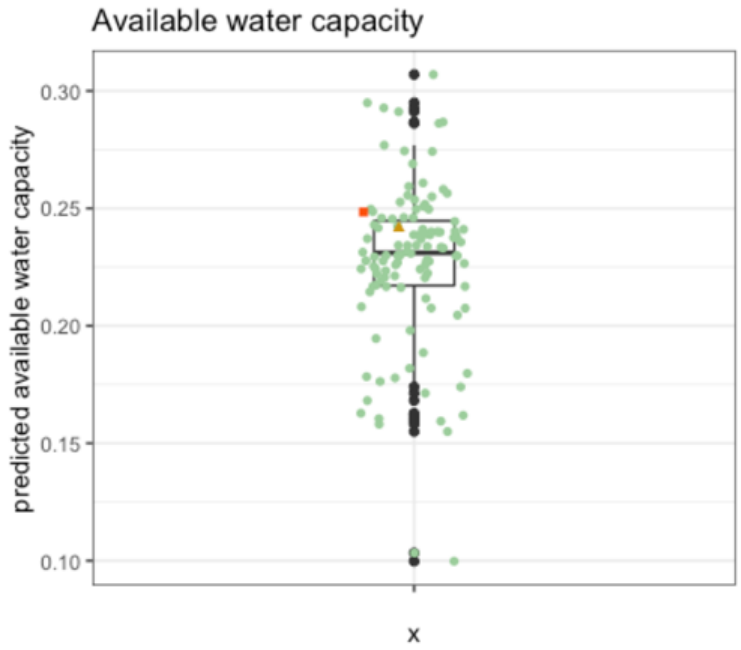
We measured two aspects of biological diversity using a carbon substrate utilization test. We took some of your soil, mixed it into solution, and then fed it to 31 different carbon sources in triplicate on something called an EcoPlate. Then we measured the amount of each substrate that has was consumed over a period of 72 hours. There are two summary statistics from this test that are useful for comparison. **Community metabolic diversity (CMD)** is a measure of the functional richness of the soil microbial community. It is a count of how many of the 31 different carbon substrates are being utilized by the microbes in your soil. **Average metabolic response (AMR)** is a measure of how much of each carbon substrate is being consumed by the microbes in your soil within the time period. This is a measure of how vigorous respiration is. We are still exploring the ways that we can interpret the information about the individual carbon substrates.

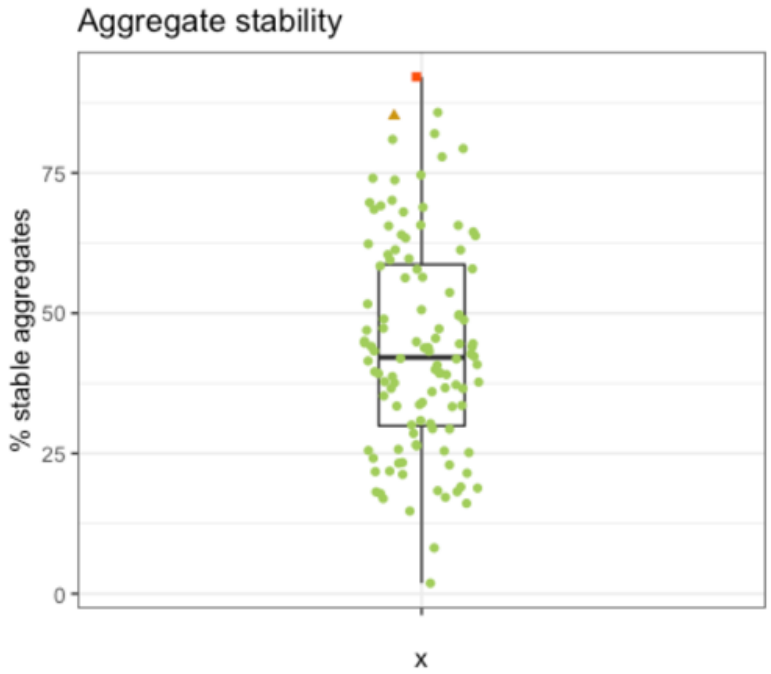




Climate resilience

Two of the things we measured are indicators of the soil's capacity to absorb, withstand or recover from extreme precipitation. **Aggregate stability** is a direct measure of the soils' capacity to withstand erosion from simulated rainfall. The reported value is the percent of stable aggregates remaining after simulated rainfall. **Available water capacity** is the plant available water in soil, between wilting point and field capacity. Our soil tests measured it as gravimetric fraction, g/g. It is an indicator of drought resilience.





Thank you!

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